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ABSTRACT

This case study documents the pedagogical changes an inner city, secondary school math teacher made as she attempted to help her students learn to use their minds well. Data were gathered in the 1989-90 school year. The report includes the teacher's description of her past teaching practices, notes how she began to change, describes the inner city school within which she teaches, and focuses on the introduction of the Opportunities to Learn (OTL) program, noting her role as both teacher and program coordinator. The report goes on to present a typical day in the teacher's life, comparing her OTL and traditional classrooms. It discusses changes in her teaching, which were inspired by her membership in the Coalition of Essential schools (e.g., projects and problem solving, cooperative skills, textbooks as resources, teacher-as-facilitator, and quality before coverage). It also notes difficulties in the midst of change (e.g., fear of change and difficulty making changes), and it discusses factors that facilitated change (the students, empowering leadership, a chance to practice change, and a framework for change). Common Principles of the Coalition of Essential Schools are attached. (SM)

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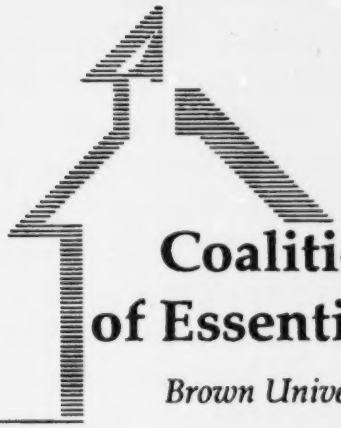

Coalition
of Essential Schools

Brown University

A Formula for Making a Difference

A Math Teacher in the Midst of Change

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STUDIES ON TEACHER CHANGE (No. 3)

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PART I

From "Coverage" to Skills Application

"Several years ago, some of my colleagues and I visited a magnet school for the Arts and Sciences to see what we might pick up in terms of our own programs. As a math teacher, I was interested primarily in the math and science classes. Well, kids were working in groups. They were lying on the floor, sitting at tables. Everybody was working and everything, but it just looked so informal to me. I told one of my friends that it looked real nice, but that I could never do it because it was just too unstructured. Besides, I felt like kids would be cheating on tests sitting around tables like that, and I just kept wondering how a teacher could keep these kids' attention when they were all sprawled out. When we left, I let everybody know that that style of teaching was definitely not for me!

"When I was a kid, my daddy used to say to me, 'Don't let your mouth write a check your body can't cash.' I guess I did that very thing because look at this classroom now!"

We were standing in the back of Jennifer Rochambeau's Algebra I classroom.[1] As I looked on, students were working in groups, some on tables, some on the floor. Some were standing up, others were lying down. There were no desks, only tables, no rows, and very little visible structure — the very image of the classroom she had rejected just a few years earlier. Students were working together, quite absorbed, and paid little attention to the two of us as we watched them work. Obviously, in the last couple of years she had changed her pedagogy significantly. I wanted to know more: What were these kids doing? How had Jennifer taught before? Why had she changed? What prompted her to change? Did she really believe that these students were learning better sprawled out like this than they did when they were sitting upright in desks? While her students continued to work, she began by describing her teaching practices and beliefs as a conventional[2] high school math teacher.

A CONVENTIONAL MATH CLASSROOM

"I've taught now for sixteen years. For twelve to fourteen of those years, I taught the way I learned to do in higher education and the way that was modeled for me as I grew up. My desks were in rows and my room was quiet. My classes were fifty minutes long. I began by reviewing the homework assignment from the night before. First, I'd call out the answers while they marked their own papers. I'd ask the students to tell me which problems they had trouble with; I'd work those problems for them at the board or, in recent years, on the overhead. If they wanted me to work all twenty problems, I'd work all twenty. If they only wanted me to work three, I'd do three. I worked the problems by copying them out, working the solution, then checking my own work so they could see how I did it.

"When we got all of their problems worked, we'd move on to the next lesson. Following the book, I'd demonstrate the next kind of problem. Then, I'd work a few examples. Finally, I'd assign homework and they would spend the remaining time working those problems on their own. For instance, in Algebra II, if I wanted the students to learn to solve equations by using the quadratic formula, I'd give them the quadratic equation on the board. I'd explain it, and I'd work a few examples — I'd plug in a few numbers. Then I'd give them practice opportunities where they plugged different numbers into the formula. Then we'd take the chapter test. I tried to break everything down into little steps so that the kids could get it.

"The pace in the classroom was very fast. In math, there is always so much to cover. I always felt I had to get through the entire book so that the students would be ready for the next level math course. As a result, there was always pressure to keep going, to move along. We moved through the textbook sequentially for the most part. I used the chapter tests provided in the book as a means to assess the kids. Every so often we had pencil and paper quizzes so that I could see how they were doing. I never had the students working collaboratively because I believed that they needed to know how to do this on their own. Working with someone else to me meant that one student would do all the work while the other goofed off.

"Throughout my teaching career, I have received good evaluations from my principals. In more recent years, my principal has sent me letters commending

good teaching — which I ended up not liking too much because they generally meant that he was going to ask me to do something else! Still, I have always felt that I was a good teacher. I went into teaching intending to be better than most, and I've worked hard to achieve that goal.

"Maybe the most important indicators that I was doing a good job came from those parents who stopped me in the grocery store to say that their teenager really liked my class or that I'd made math come alive for once. Then, every year I had some students who came back from college to say that they were doing well and appreciated the preparation they'd been given.

"For years, I believed that I was doing the best I could, that not all kids were cut out to do well in math, and that that simply was the way it was. So I concentrated on getting the greatest number I could over onto the good side of the bell curve. I believed that my professional responsibility was to follow the principal's directives and to cover the material presented in the math curriculum."

THE BEGINNINGS OF CHANGE

"When I moved to this school, the math department was stronger than it had been in my previous school. The whole department ate lunch together and would meet in the mornings for a few minutes to drink coffee. In those conversations, I learned that some of my colleagues were really unhappy with the design of the textbooks and were skipping around in them. Gradually, through these conversations, they helped me to realize that the order of the material in the texts was more arbitrary than I'd imagined. Then, they helped me to see that I could generate more complex tests, that the book tests simply asked the kids to plug in numbers, but didn't enable them to really think seriously about application. So, in our department, we did lots of talking and experimenting in order to find better ways to help the kids understand math.

"While I felt I was doing a good job, that I was a strong teacher, that I really cared about my students, I also felt I often moved too fast for the students, or sometimes I was impatient with the students because they couldn't keep up. After a few years of teaching, everything about math seemed so logical, so straightforward, that I couldn't figure out why it stumped the kids so much. And I felt frustrated. Every year, they'd get stuck in the same places. Every year, they really required more time on some chapters than the pace of the curriculum would allow. Frankly, I didn't know how to deal with these feelings I had, other than to share them with my colleagues in the faculty room.

"Then, a few years ago, the principal was doing his doctorate. (We used to all pray for the day when he'd finish so he'd stop trying to get the rest of us to go to school with him! He was always putting articles about education and about teaching in our boxes.) He was invited to Brown University, where he heard about Ted Sizer's work and about the Coalition of Essential Schools.[3] He came back and started talking to the rest of us about what he'd learned. He'd had a major insight about our school. He said that when he'd walked down the halls of the school, he'd felt very good because all the kids were in their rooms, at their desks, and the school was a quiet, industrious place. Then he realized that he didn't know if they were learning, because they were playing such passive roles. This was a *big* learning for him, and he sure did not want to let it drop. So the next year he sent a couple of us to Rhode Island to workshops. I must admit I did not see how any of the techniques the presenters were talking about would work in math.

"Finally, he sent another group of us off to a Coalition symposium in Louisville, Kentucky. Now, I have to tell you how I saw my role at this conference. I went to the symposium to get ideas to bring back. I believed that the principal had selected me to go because I was a good teacher and I would be able to sort through all the garbage that was being said to bring back the good stuff to the teachers in my school who really needed it. And I was prepared to do just that.

"Well, I found myself in a session with Amy Gerstein on Math and Science. She started by asking us how we believed classrooms should be organized if kids were to learn well. The group yelled out all kinds of good and fancy stuff: fewer students, more real-world experiences, more problem-solving or application of abstract concepts, that sort of thing — every teacher's dream. Then we proceeded to do the 'Ain't it awful' routine. You've heard it: 'We can't do those things because of this rule or that bell or the after-school schedule or the curriculum guide — too much to cover.' She asked us how we dealt with the curriculum guide currently. We said not very well. And she asked why not. We got hot and said 'Because we don't have any decision-making power; we do what the principal tells us!' And on it went.

"Over the course of a couple of days, Amy forced us to clarify what it was we wanted to do and then started showing us that *we* were the primary obstacles to teaching that way. You know, we'd never felt like we had the authority to make decisions like that. Well, I can tell you, our van was four feet off the highway with all the ideas we had on the way home! I guess that was sort of the beginning of my personal commitment to change, and to the team effort, too."

RIVERDALE HIGH SCHOOL

Jennifer had begun her career in an inner-city school in a Southern city of 350,000. In her eighth year, she transferred to a suburban high school that was part of the county school system. Riverdale High School served 11,000 students in grades 10 through 12. There was no busing, so the school reflected the community population: 90 percent were white with a small minority group, mostly African-American. There were sixty people on the faculty, which had recently been influenced by 60/40 legislation that required all school systems in the state to have 40 percent minority teachers. To meet this requirement, white teachers from the school had been transferred into the city system, while black teachers had joined the staff at Riverdale. A new superintendent had been brought in the year before with a charge from the board to clean up the system. He was the first African-American superintendent in the county system.

Riverdale was a fairly typical American high school. Students had the opportunity to select from a smorgasbord of courses, from industrial arts to languages. They were required to take the core subjects (English, math, social studies, science), with additional requirements in the arts, physical education, and a few others. Students then chose elective courses to round out their program. They were tracked according to ability and for the most part attended classes with students their own age.

The school plant was filled to capacity. Four lunch sittings had to be scheduled because space was so limited, and expansion of the cafeteria was a constant topic of conversation. Built in the fifties along the banks of a stream, Riverdale was a big, sprawling place. A series of fields surrounding the school allowed a number of athletic teams to practice at the same time. All the buildings were clean, well lighted, newly painted, graffiti-free.

The OTL Program

When Jennifer and her colleagues returned from the Louisville conference, they had descended on the principal with a proposal to experiment with Essential school ideas. With his wholehearted approval, they had established an interdisciplinary team of teachers who agreed to take responsibility for one hundred tenth graders who had done well in school up to sixth grade but then had hit a slump, students who would typically be labeled "at risk." Jennifer developed a separate schedule for the students, and the team selected the kids based on their achievement scores. They called the program "Opportunities to Learn," which was quickly shortened to OTL.

The first year was very hard. The teachers found that the kids had tremendous needs and just plain didn't feel good about themselves or their abilities. The teachers worked very closely with the parents, some of whom liked the program, some of whom were skeptical. The kids hated being different. Unlike the rest of the school, their schedule was double-blocked, and they were divided into four groups so that each teacher saw two groups every other day for two hours. They didn't like not seeing other students for a good portion of their day. And, most significantly, they found it very difficult when the teachers asked them to work in different ways than they had been asked to work in school previously. The teachers were experimenting with the principle of student-as-worker.[4] Students were required to play a much more active role in the classroom, whereas they had grown accustomed to relatively passive roles.

While the teachers and students had persevered together throughout the year, they all agreed that some changes needed to be made for the next year. This year, the second year of the program, two teams had been assembled. The tenth-grade team worked with a hundred new students, while a new team was formed for the rising group of eleventh graders. This year the teams agreed to select a heterogeneous group from among students who volunteered for the program. The schedule was single-blocked so that each of the team members saw each of the students every day. The tenth-grade team consisted of a biology teacher, a math teacher, a world geography teacher, an English teacher, and a life skills and health teacher. The students for the most part stayed together for five periods of the day. Jennifer developed the schedule for both groups of students and adults.

Jennifer and Her Role

Jennifer functioned as both teacher and coordinator in the program. She taught two classes in the OTL program, had two release periods to coordinate for the other OTL teachers, then taught two regularly scheduled math classes as a member of the faculty in the larger high school. Her schedule was:

7:30 – 8:25	OTL Algebra I
8:30 – 9:25	OTL Geometry
9:30 – 11:30	Program Coordination
11:30 – 12:00	Lunch
12:00 – 12:20	Lunch Duty
12:25 – 1:15	Geometry
1:20 – 2:10	Algebra I

Jennifer had been asked to coordinate the program by the principal, Dr. Jamison, because she was both well respected by her colleagues and committed to the program. During the double planning period, she met with the two teams, ran interference for them, gathered materials, met with students and parents, organized special activities — whatever needed doing so that the other team members could concentrate on their teaching. She functioned also as liaison between the team and the principal. She generally tried to find a few moments each day to share their plans with him, to ask advice, or to ask for his support in some way.

She had a very good relationship with Dr. Jamison and believed that he had done a tremendous amount for their school. He had recently announced that he would be taking another job the following year and she was nervous. Another principal might not be so supportive; she and her colleagues agreed that they had not been treated with so much professional respect by any of their previous principals. He expected them to carry the program and to solve the problems that went with it. They had become accustomed to making their own decisions.

Jen, like all the faculty members, attended one of the principal's monthly Quality Circles group. Each group consisted of a cross-disciplinary section of the faculty. The purpose of the meetings was to exchange ideas about education and about the school program in small groups so that everyone's voice could be heard.

Over the previous few years, as Jennifer had heightened her involvement in changing her own instruction and in changing the school. She had come to believe that her professional responsibility had changed. "I think I have an obligation to work with my colleagues, to take a stand on what is good teaching and what is not. I think my job is to work to ensure that every kid gets the very best we can give him or her. I feel that it is my responsibility to make decisions about what should be covered when and how, because I am close to the kids and I know what they need. I feel more professional somehow because I am more involved in trying to understand what teaching is all about.

"I also feel I am involved in a very important movement to change public education. In order to participate, I want to read as much as I can, I want to find out and learn as much as I can. I think the kids in my classroom have benefited from that because they see how excited I am when I'm learning, how enthusiastic I get."

Jennifer Rochambeau was no slouch in the energy department; there were days when I thought she made the teenagers look slow. She was professionally energetic and then had a full family life once she left school. She held a Masters degree in Educational Administration and belonged to a number of educational organizations — the Association for Curriculum and Instruction, the Math Teachers Association, and a small cooperative math project at the local state university campus. She was certified at the top level of her state's career ladder program, something she had achieved before she became involved in the OTL program. In order to fulfill her responsibilities as a state mentor teacher, she was in the process of organizing an innovative summer high school staffed by interdisciplinary teams of teachers and attended by inner-city kids who were at risk.

In addition, Jennifer had just been selected by the Coalition to participate in a program through which teachers would assist other teachers in the process of change, so when she finished her local summer school, she planned to leave for the East Coast for a month. Over the next few years, she would be spending a percentage of her time helping teachers and principals in other schools work toward school change.

In the course of very busy days, Jennifer was even-tempered, optimistic, and well organized. About five foot six, she had eyes like Princess Di — river green with thick lashes, very striking. Those eyes revealed a good deal: a sense of humor, a quick mind, a question. Her friends teased her that when she was excited she could talk faster than the speed of sound. The most remarkable thing was the

speed at which she could talk and still sound like a Southerner. She had a good, easy relationship with her students, and a similar manner with her colleagues, but when quick action was required, she could be brisk, to the point, and efficient.

Jennifer was fortunate to have a husband who was very supportive of her work. They had been married for sixteen years. While he originally had wanted to teach, they found it too difficult to live on a two-teacher income, so he went to work for a local business. They had two small sons who were into all kinds of sports, so the coordination of meals and schedules was quite a trick. Jennifer noted that she wouldn't have considered many of her activities if her husband hadn't encouraged her and worked with her to take care of the house and the boys.

In a moment of quiet, away from the bustle and immediacy of the school, she confessed her fears. "The three men in my life are my greatest blessings. Each time I take a step toward greater involvement in changing public education, I feel as if I am stepping away from them. I'm afraid of that; they are more important than anything else I do."

PART II

A Day in Jennifer's Classroom

Jennifer's day started very early. She arrived at school between 6:30 and 6:45, grabbed a cup of coffee in the faculty room, said hello to her colleagues in the math department. She then checked in with the principal, grabbed the daily pile of mail [illegible] her box in the main office, and headed up to her room on the second floor. The room was brick, painted pale yellow. It had one window facing the fields, two blackboards, and an overhead projector set up midway down the room. The overhead screen covered the clock. On the bulletin board there were questions in bright letters:

So what?
What does it mean?
Where have we seen this before?

As she arranged the materials she would need for the day, two visitors arrived with a video camera. They were from the state department of education and had come to videotape her teaching as a means by which to check the rating scale recently developed to evaluate teachers for the career ladder program. Originally, the rating scale had been devised to encourage teachers to use methods described in Madeline Hunter's Instructional Theory into Practice model.

Jennifer had used those methods during her own evaluation but had raised questions about them immediately. She believed that some of the techniques she was regularly using were more effective with kids, but that the rating scale would penalize such teaching. The head of the career ladder program had come out and watched her teach, agreed with her, and sent this team out to see what they might do. One of the visitors was surprised that she had tables in her room instead of desks. Her response: "I just can't imagine how I could possibly have taught math with those piddly little desks!"

TWO OTL CLASSES

Jennifer's two morning classes were part of the OTL program, first Algebra I, then geometry.

OTL Algebra I

The twenty tenth-grade students in Jen's OTL Algebra I class were in the room and at their seats when the bell rang. Jennifer started immediately.

"Coaches, please take roll for your group. The roll sheets are here on the desk. I'd also like you people to document your group's progress each class period for the duration of the project we are about to begin today."

Jennifer stood in the middle of the room at the overhead and made eye contact with each student. The kids were spread around her at their tables.

"How is everybody? Y'all rested up and ready to go?" They groaned, grinned, tossed out important comments.

"We won our basketball game on Saturday, Ms. Rochambeau."

"I'm real tired, Ms. Rochambeau. We didn't finish play practice till eleven o'clock last night."

Jen grinned at the student. "I don't want you falling asleep today in here, Rodney. Save your nap till lunchtime."

The coaches picked up roll sheets (on which all the students were grouped by team with an asterisk next to the coach's name), filled them out, and sent them back across the room to Jen.

"Okay. We're starting a new project which will take up a week and a half. So, what day is your project due?"

They chorused, "Next Wednesday."

"I want you to plan a vacation. You can plan what you will be doing for spring break with your friends or you can help your folks plan the family trip this summer or you can make one up — whatever suits your fancy. I'd like you to include the following things in your project: 1) a geographical description of the area; 2) a detailed budget; 3) a graph to report the percentages of your budget allocated in different categories; and 4) an oral presentation to explain your trip. You'll be evaluated on three aspects of your project." She handed out a sheet that described both the project and the ways in which they would be evaluated. (Jen had a computer at home which helped her enormously in the preparation of

projects such as this one.) The evaluation included the following:

1. A computational component to include your budgets, your graphs, and the work you do on how you'll get there and get home. This will be worth 100 points.
2. A visual component to include illustrations, diagrams, charts, and graphs to help us understand your journey. This will be worth 50 points.
3. A Self- and Group Evaluation: Each of you will assess your own performance on a point scale of 1 to 10. The group will evaluate your ability to work together from 1 to 15 points. The group must reach consensus on the score. Both of these evaluations must come in with a brief written description of the award.

"Any questions?"

The students began to talk among themselves about where they would go. No one seemed confused or dismayed. Jen recalled their attention.

"Okay. Let's work for a minute together. Where do you want to go?"

One student yelled, "Russia!"

"Why, Amy? Why is Russia interesting to you?"

"Because of everything that's going on there now. Like, everything is changing and it would be real interesting."

"If you were going to Russia, where would you think about going?"

Everyone chimed in. "The Kremlin."

"Red Square."

"Moscow."

"Siberia!"

Jen nodded. "It's a big country. What do you need to do to figure out where you're going to go?"

"Figure out distances."

"Figure out how much money you have."

The students were warmed up and seemed eager to get started. They had no difficulty answering the questions she tossed to them. Jen handed out a second sheet with a set of instructions:

1. List the resources or manipulatives you'll need for your project.
2. Construct a timeline to show how you will complete the project by the assigned date.
3. Identify the math skills or concepts you will be applying.
4. Estimate the total cost of your trip. Keep the estimate so that you can compare it to the actual cost when you've completed your work.
5. Construct a work schedule to show each person's responsibilities.
6. Design a method of graphically showing each of your budget categories.

"I want y'all to take the remainder of the class period today to plan how you're going to work on these tasks. Please work on the sheets of big paper which I'll bring around. We'll stop about ten minutes before the end of the period so that the coaches can report the progress you've made. Do good work, now!"

As they began to work, she moved from group to group. One group of boys was unfamiliar with the word "consensus." She asked questions to get them to extract the meaning out of the context:

"How do y'all make decisions about rewards and punishments at home?"

"Dictatorship."

"Well, what is consensus then?"

"Democracy."

"How are decisions made in a democracy?"

"Majority rules."

"Does everyone agree when the majority rules?"

They eventually worked around to an understanding of the differences between a dictatorship, a democracy, and consensual decision-making.

Another group discussed how you get to the Bahamas if you don't want to fly. Another talked about time changes in Australia, gaining and losing a day. Several of them had not considered this before. Jennifer circulated to each group. With some she sat down for a few minutes. With others she just leaned in to listen and to ask a few questions. The pace of the class was brisk and the atmosphere friendly. Near the end of the period she asked volunteers from each group to share their progress. She reminded the kids that it was okay for them to borrow ideas from another group. Three boys stood up to share the information on their big sheet of paper, which read:

To the BEACH in Florida:

1. Materials we'll need: poster boards, markers, road maps, pictures.
2. Jed will go to the travel agent. Mark will get road maps from the Shell station. Tom will figure out food and stuff.

3. Addition, subtraction, multiplication, division, DRT (distance/rate/time).
4. Budget categories: 1/3 recreation; food is the largest chunk and lodging is a small chunk.

Jennifer asked them if they knew how to calculate all of these things. They said, "We'll talk to you after class." Everyone laughed. Jen noted that the whole class was going to have to talk about these calculations in class.

A group of girls presented their ideas about a trip to the Caribbean. Their graph included categories for food, airfare, lodging, car rental, and $450 for clothes shopping. Jed, the coach in the first group, said, "We don't need clothes; we're going to be on the beach the whole time." The class roared.

As time ran out, the pace of the class picked up. Jen asked each of the groups to put their worksheets up before they left. She reminded them of their homework — to make paper airplanes and bring in empty milk jugs. She told them to dress for going outdoors the next day and asked the coaches to write a few sentences about their group's work for the day. As the bell shrilled, the kids poured out of the room.

In the five-minute break, Jen answered a few questions for the videotapers as they packed up to leave. She waved to her student teacher, who was working in another classroom for a few days. In between, she explained the sequence of activities that would take place during this project. The next day, students would learn to measure time, rate, and distance by flying paper airplanes outside on the field and by floating a few empty milk jugs down the river on the school grounds. On Wednesday, they would work on building pie graphs, review percentages, learn how to establish the vertex, and review what should be included in their budgets. On Thursday, they would have a day to work in class and to write up their progress reports — where they were and where they were having problems. She would give them two more directed lessons, one using maps to calculate distances and another on interpreting graphs. Then they would have one more day to complete their work in class. Their written report was due on Wednesday of the following week. On Thursday and Friday, the oral reports would be given.

Jennifer noted that it was more difficult for her to generate projects in Algebra I, where students were just developing the skills they needed. She felt that this particular project did not represent pure algebra but blended a little algebra with general math skills. She believed this project was good because the kids reviewed some skills they had learned previously and picked up some new ones. She laughed as she described how liberating it had been for her when she decided she could legitimately pull material from different parts of the book, when she discovered that she didn't have to go through the material in the order in which the textbook presented it.

OTL Geometry

The next group rolled in, seventeen eleventh-grade geometry students. This group was in the midst of a project in which they were to design or redesign a room or an area of their choice. One group was designing a golf course. Several others were remodeling rooms in their homes. Another group was designing a weight room for the school.

On the first day of the project, the students had done the same activity that the Algebra I class had just gone through. Around the room were their big sheets of paper describing their projects. They identified the materials they'd need, the computational work they'd have to be able to do: figuring area, volume, perimeter; working with fractions, decimals, percentages; all the skills associated with budgeting. The sheets also described their timelines and who would do what.

On the second day, she'd given them the "dog-pen problem,"[5] which stated in part:

> Mr. Garcia has a new dog named Cosco. He wants to build a pen in his backyard in which Cosco can play. His neighbor, who works at a building supply store, gives Mr. Garcia 80 meters of chain-link fencing. Of course, Mr. Garcia wants Cosco to have as much space as possible. What is the largest pen he can build using the 80 meters of fence?

The problem had several additional twists and turns once the students had learned to figure out the area. They began to see what happened to area when they chose different shapes. Each group put its solutions on the board and discussed the advantages and disadvantages. They quickly began to see why buildings are of such uniform shape.

The third day of the project, students brought in the problems they were beginning to face. Jen had asked the industrial arts teacher to come in and

work with her students while she worked with his. He took each group's problem and worked it at the board for the students.

Today, she had prepared a graphing activity to help them develop interpretive skills when reading graphs. In their groups, students were given a set of statements and questions. For example:

1. Prices are rising more slowly now than at any time during the last five years.
5. If movie admission charges are too low, the owners will lose money. If they are too high, few people will attend and again they will lose. The theatre must therefore charge a moderate price to stay profitable.
6. How does the cost of a bag of potatoes depend on its weight?
8. How does the time for running a race depend upon the length of the race?

The students were given a set of fifteen graphs. Their task was to match these statements to the graphs.

(For the full exercise, see Appendix B.)

While the coaches for this class did the roll, Jen handed out the sheets they would need and gave them instructions. "All right, y'all. I want you to work in your teams to do this. But you must reach consensus on which graph belongs to which statement. When we're done, in about twenty minutes, I'd like you to be able to defend your choices and put them up on the board. The coach will appoint a spokesperson from each group. Y'all ready?" The groups moved right into the work.

Announcements came over the loudspeaker: "Fellowship of Christian Athletes need to pick up scholarship applications from Ms. Frank. All students going to Boston must meet in room 202. Mandatory, but brief. Absence forms must be in by noon on Tuesday. Prom Committee meeting in Ms. Brown's room today. The boys' tennis match has been cancelled. . . ." The announcements went on for another five minutes. Students listened or worked quietly.

Jennifer moved from group to group. Three boys were hunched over the sheets. One wore an ROTC uniform and sported a crew cut. Another had an earring, a long ponytail, and sported a rocker T-shirt and jeans. The third was clean cut and dressed out of an L. L. Bean catalogue. They were working on statement #5.

"What about K?"

"Can't be; too high."

"What about O?" Silence while they considered.

"Nope, I think it's N, because if prices are too low, they'll lose money. And if they're too high, they'll lose money." They all wrote N on their papers.

One student groaned, "Where does she get these things? These aren't written in English; they're written in German!"

Jennifer moved around to every group. She stopped with some who needed help, just listened with others. After twenty minutes, she asked them to put their work on the board. There were seven lines of figures on the board when they finished. It quickly became apparent when there was consensus and when there was disagreement. Consensus was infrequent.

Jennifer asked them to resolve the disagreements. "Okay, y'all, find the two most common answers for #1. Then I want volunteers to defend each of the answers." The students engaged in a rousing debate. No students raised their hands. Jennifer did not interfere, as the students seemed well able to monitor the discussion. Her role was to ask, after each answer had been defended, "Which one is it?" and then, "Do we have consensus?" When the class did not agree, she asked additional people to explain the choices they had made so that the circumstances would become clearer for the whole group.

Toward the end of the period, she stopped them to ask a few questions. "How do you feel when you can't find the right answer?"

Tom replied, "I hate it. It makes you feel uncertain."

Jennifer grinned. "Are there more right answers out there in the world than uncertainties?" The kids debated that for a few minutes while Jen helped them to distinguish between factual circumstances and hypotheses. She shared with them that she was reading a book about decision-making and that most "answers" are choices people have made based on the best information available at the time. She asked them what that meant for them. One of the students said it meant that they have to get good information.

As the bell rang, Jen reminded them that a progress report on their project was due the next day. The students said good-bye as they left. One student stopped to tell Jennifer that she'd loved the day's activity because she loved to argue.

TEAM PLANNING PERIOD

Jen spent the next two periods meeting with the tenth- and eleventh-grade teams. The tenth-grade team met three times a week, the eleventh-grade team usually once a week. She used the remaining time to organize the activities and materials they were all working on and to do the liaison work, the scheduling, and her own planning.

They met in the Commons area, which was also the cafeteria. The tenth-grade group — a biology teacher, a math teacher, a world geography teacher, an English teacher, and a health and life-skills teacher — consisted of four women and one man. As they gathered around the table, much of the talk was about grades, who had failed what, how they were allocating their grades, whether they were done, when the actual final deadline was. Jennifer reminded them to put positive comments on each kid's report card. "We're trying to build these kids up, you know." She handed out a sheet listing the discussion topics for their meetings for the week. It also included important events about which she wanted to remind them.

They launched into the first agenda item: how they were going to organize next year's eleventh-grade schedule and whether this team wanted to move forward with their students. Most did. Jen noted that the current eleventh-grade team wanted to move forward with their students. She pushed them to talk up preregistration for the program with their students, as their plans would rest with the number of students who chose the program.

They discussed a field trip to the state capital later in the week. Jennifer reminded them about the principal's Quality Circles meeting the next day. The whole school was considering experimenting with a double-blocked schedule, and that was to be the topic of the meeting.

They talked about grades a bit more. Jen again pushed for positive dealings with students. After several more announcements, Jen asked, "What else do we need to worry about?" They went back to whether they should move forward with their students and remain as a team or whether some of them should stay with the tenth grade so the new team would have at least some experienced people on it. They couldn't decide. There were advantages and disadvantages both ways. They batted it back and forth until it was time to go.

Sam, the geography teacher, left first. The women noted that he had been down lately. They talked about why and what they might do for him to perk him up. They decided to take him to a local restaurant for lunch on Friday and to cover his classes for him for two periods that day. They laughed about the fact that they had better go out to lunch while they could, since the current principal was leaving at the end of the year. Jennifer wrote herself a note to swap lunch duty that day. As the bell rang, they raced off in four different directions. Jennifer walked one of the teachers to her classroom so they could discuss what to do about a difficult student.

The eleventh-grade group assembled in much the same way. This team consisted of two math teachers, two English teachers, and one counselor — again, one male and four females. Jennifer handed them their own schedule for the week with discussion topics. They talked about registering the twelfth-grade kids. One of the teachers noted that the school counselors were advising kids against the program; one student had been told that the program would adversely affect college admission. Jennifer's face absolutely fell.

The group talked about the fact that resentments among the faculty were still pretty substantial. People didn't understand the reduced student load; they felt the teams had been given special privileges. One of the English teachers reported that those teachers who were not supportive of their work were doing some lobbying among the other teachers. They were hoping that when the principal left, the whole program might be scuttled. It was apparent that the entire staff was concerned about the transition. Jennifer asked for volunteers to go with her to talk to the counselors. She noted that she perhaps did not do the very best job of preparing them for the registration proceedings and that they might use this as their opener.

The conversation shifted to how they might better communicate to the larger faculty what they were trying to do. Some suggested opening it up at the Quality Circles meetings, which all faculty attended. They considered an update memo, but feared that folks would be too busy to read it and that those who weren't supportive wouldn't take

the time to read it anyway. Jennifer asked that they continue to think about this while she talked to the principal. She was visibly discouraged; she felt that they had worked very hard to keep the faculty up to speed and thought that they had reached the stage where their intentions and interests were pretty clearly understood.

The subject changed to which of the students might be in trouble with credits for the second semester. They generated a few names and split the responsibility for locating the kids and talking to them. Jennifer volunteered to check with the counselors about these kids and to contact their parents. One of the teachers talked about a student who had been depressed. The group agreed that a meeting should be called with his father, since the boy seemed to be potentially suicidal.

Concerns about new interruptions to their class time surfaced — teen challenge, visitors from other schools. The time flew by. Jennifer added a few discussion topics to her list for the next meeting, and they dispersed.

At lunchtime, Jen grabbed a sandwich and went back to her room to complete her own grades before doing lunch duty. She managed to finish several before racing back to the Commons area to visit with students and remind others to put their trays away and to pick up their garbage. She confessed that this was the sole responsibility as a teacher that she hated. She felt that it forced her into a kind of relationship with kids that did not foster respect and understanding. "Teachers who are trying to encourage kids to believe in themselves and to work harder should not also have to play a policeman role."

TWO "REGULAR" CLASSES

After lunch, Jennifer taught two more math classes. These were not classes in the OTL program and consequently were much larger, reflecting a more traditional student/teacher ratio: twenty-eight in one class, twenty-seven in the other. She noted that it was much harder with the larger group to do the kinds of activities she was doing with the morning classes. There were more groups to get around to. It was more difficult to keep track of who was doing what. The noise level was higher,

Still, she experimented occasionally. This week she was having these classes do the same activities as the OTL classes. In general, she did not keep the two sets of classes on the same track, but she noted that her teaching with these groups, too, had changed. Instead of having the kids work individually, she paired them to do their homework, requiring that they both show the steps they had taken to arrive at the solution. Instead of working their homework problems for them at the board, she now asked them to demonstrate those that they had had difficulties with so that it was the students who worked at the board.

While Jen worked with her afternoon classes, I went across the hall to Paulette Miles's room. Mrs. Miles was head of the math department and also on the eleventh-grade OTL team. "Paulette's been my mentor in all this change business," Jen told me, "and the best part is that she's been teaching to the Coalition principles all her life. She is the one who really started us thinking about the organization of textbooks, about the sequence in which we should teach things, and about the way in which we might teach math. She's really an innovative teacher."

AN INNOVATIVE GEOMETRY CLASS

Paulette was just setting her OTL geometry class into motion. Her classroom was next door to the computer lab. There was a glass window separating the two so that students in her room could watch what was going on in the lab and vice versa. "All right, y'all. I want group three to go next door to work on Geosupposer. Work in pairs, please. I want y'all to do some proofs. You get set up and I'll come over and give you directions. Okay, the rest of you need to spread out into two groups. Five students in each group. Opposite sides of the room, please. This is to strengthen your concept of similarity. You don't need me for this activity, but it's not as simple as it seems. I do not want you to put any answers down until your whole group agrees. Believe me, you don't need me! No questions until you've worked it all out."

She handed out a problem sheet. There were thirteen problems on similarities. The two groups hunkered and got to work. (This exercise is presented in Appendix C.)

Paulette walked over to the computer lab and moved from group to group. The software package was new, sent to her by the central office to experiment with. She did not want to give it up, as it added a whole new dimension to geometry. She sat down with two girls who were drawing a triangle. "Can you enlarge that for me, please?" She helped

them to change the scale. She gave them a series of lines and angles and then asked them to draw some conclusions based on the angle bisectors. One of the girls observed that "all the angle's bisectors meet at the same point — at the center of the triangle."

"What is the center of a triangle?" She pushed the girls with a series of questions. Consistently she asked them to tell her how they knew what they knew. "If you know *why* you know what you know, then you're much less likely to make any errors." She asked them to think about definitions. The girls went on to prove that two of the triangles were congruent. They both talked, watched the screen, and wrote in their notebooks.

Paulette popped back into the other room. "Everyone in agreement?" Neither group was. "You have five more minutes before you switch to the computers. Keep going. You can do this." After five minutes, she had the groups switch.

The girls who had been on the computers formed one large group to work together back in the regular classroom. They were given the problem sheet and set to work. Almost immediately they got stuck. One called for Mrs. Miles. Another one stopped her, saying, "Don't call her yet. We can do this. She'll really give it to us if we can't figure this out." They hunched over the problem again. One girl suggested a solution. Another critiqued it. A third suggested a new possibility. They did this without looking up from the paper or seeming to mind the criticism. At one point, the group completely disagreed and dissolved into five separate conversations. One of the girls rapped the table to bring everybody's attention back.

Despite having two very different activities working in two rooms at the same time, Paulette managed to get around to everybody and to monitor each group's progress. In between, she explained her philosophy of teaching math.

"I've taught for twenty-two years, and I've always taught this way. Last year my Algebra II students did a timeline in mathematical history. They each picked a period and researched mathematics during that time. They made oral reports and gave the class some problems to work. They also did a written report. We put the whole timeline up on the wall. One night it fell off and tripped the burglar alarm, so I got these nice moldings put up all around my room for the projects the students do." She was clearly pleased.

"My other class just finished doing Miles Bowl. They make up math games. The game must review every math skill we've covered and must challenge other students." She brought out several games that had been hits with the students. "The students are much more inventive than we give them credit for!"

Paulette had been a fairly traditional math teacher for her first few years in teaching, then stayed home to have a child. Watching her own child, she developed a new philosophy — no one learns well unless they want to. So she began constantly to look for ways to get students involved and to let them shape much of what they did in mathematics. "Whoever told teachers that math had to be taught from the book from front to back had never seen kids learning!" She noted that as math department chair, she had little opportunity to influence change, for the very same reasons — because people generally only learn what they want to. She felt that since she had been working on the interdisciplinary team, they'd all begun exchanging more ideas and that the math department was being influenced as a result.

Since the bell was about to ring, she signaled to the computer group to shut down and return to the classroom. She collected their computer proofs. Only one of the groups had reached consensus about how the other problem she had given them should be solved. She told them to continue working on it for homework and they would pick it up first thing in class tomorrow. The students walked out of the room, still in their problem-solving groups, making plans to get together. Several kids told Mrs. Miles they liked working on the computer. She said, "Me, too!"

As the students streamed out of the school, Mrs. Miles worked with a few students, checked computers, collected software, and reorganized for the next day. The pace of the day slowed, a winding-down. Jennifer poked her head into Paulette's room to see if they might work together for a few minutes. Several students came in, and it was difficult to know whose students were whose. Both teachers helped the kids with various questions they had about math. Once the students had left, Paulette showed Jennifer the computer program and the kinds of things the students had been doing. They reviewed the sheets the kids had handed in. Jennifer, who claimed she didn't know how she taught before there were computers, was excited. Jennifer showed Paulette the worksheet she'd found on graphing and told her how she'd used it with the kids. Paulette was delighted.

"This is excellent. May I use this? You are a goldmine, m'dear! This is much better than that dry little set of activities in our book."

They moved on to Jennifer's concerns about the larger faculty and what should be done. Paulette sighed and said that they just had to be patient and to keep them informed. That was the best they could do. Then they talked about a student who wished to transfer into the OTL program. A counselor had sent the student to Paulette, who had agreed to admit her. Jennifer wanted to follow that transfer up a bit more closely to find out just what was going on. Her concern was that students coming in mid-semester compromised the integrity of their program. She wasn't sure whether the counselors were using the class as a dumping ground, or whether they knew that the teams were trying different teaching techniques that required that they have fewer students. Paulette agreed to send the student to Jennifer so that she could do more investigation. She said, "You know, Jennifer, I have always been such a soft touch with the kids. I do believe that you are trying to save me from my own self, to protect me."

It was getting late, nearly 4:00. Jen gathered up her stuff, giving Paulette a kind of sheepish wide-eyed smile. "Well, there's a little of that, but mostly it's that I think we could be working up a pretty good formula for making a difference with these kids. You know better than I do that we have to keep the variables to a minimum to figure out if it's a good formula or not! Now, much as I love you and your company, Paulette, I've got two handsome boys waiting on me. I'll see you tomorrow."

PART III

An Examination of Teacher Change

Jennifer Rochambeau's math classes were lively and engaging, and they were very little like the math classes I had as a kid. In most math classes in which I have either participated or observed, students come to class equipped with paper, pencils, and the textbook. By contrast, Jennifer's students were bringing in things like blueprints for golf courses, carpet and paint samples, paper airplanes, empty milk jugs, road maps from Seattle to Ft. Lauderdale. Her students were sitting at tables, working in groups, engaged in projects such as redesigning rooms and planning vacations. They were preparing oral reports and visual and written materials to accompany their reports. I asked her to explain the changes she made from past practice to her current methods, and then to think out loud about what both constrained and enabled her as she engaged in these changes.

SO WHAT'S DIFFERENT NOW?

Jennifer began her description of the changes she had made by noting the broad, structural changes the team had made at the outset of their attempt to provide better educational experiences for their students. They had formed a school within a school and built a schedule that allowed them to share a common group of students — fewer than the normal high school load. They shared a common planning period during which they worked together, planning their program and talking about their students. And they talked frequently about changing their instructional methods.

These changes were inspired by their membership in the Coalition of Essential Schools and guided by its nine Common Principles. Jennifer noted that it was within the context of these changes that she was able to examine her own instruction and to make further changes.

Projects and Problem-solving

"Once we got all of these things in place, a whole lot of changes seemed to happen all at once. First of all, I want you to realize that I don't always do project teaching. While I really love it and while the kids seem to do so well with it, I'm still learning how to do all this. For one thing, it's hard to find resources. So I try to spend two to three days a week doing problem-solving, a couple of days teaching basic concepts and skills, and I try to build in a project every term. Projects usually take a few weeks, so one is really all I can fit in right now.

"I've also changed the way I teach plain old concepts and skills. For one thing, I try to present new math concepts in terms of their application. I used to just move through the book: I'd show the kids a formula, I'd plug some numbers in; then I'd have *them* plug some numbers in, and they'd do homework applications. I'd work their problems and then we'd have a test. Now, I start by giving the kids a real problem — say I want them to learn to do quadratic equations. I begin by posing a real-life problem where kids would need to know how to solve for a square. Then I ask questions like, 'What do you need to be able to do here? Where else might you use this?' Then I go back and show the kids the formula. We work the problems together — usually a student demonstrates it while I coach from the side. Then I put them in partner pairs to tackle a set of examples. The kids seem to do much better when they are learning through problem-solving. They seem to understand the concepts better."

Cooperative Skills

"And do you know another thing I have learned? These kids don't know each other. Even though they've been in school together for fourteen years, sitting next to each other in little rows, they know almost no one outside their own small circles. So I've found I have to do a number of ice breakers at the beginning of the year — activities to get them talking to each other. I have them line up by shoe size, or we tell number stories — where they ran into good numbers, that sort of thing. It might sound corny, but the truth of the matter is, it helps them to get ready to work together. While they get to know each other, I spend a lot of time diagnosing their math skills so that I know where each student really is.

"When they work in groups, I'm better able to tell where they are really having problems,

because two kids are a lot more likely to speak up than one kid who doesn't want to look dumb. They feel like they've got some company. Their openness helps me a lot. I even do things like group or partner quizzes when we're learning new concepts. They ask me if I want them to cheat! It's hard for them to get used to the idea of cooperating. I have to help them learn how to work together — like I ask them not to ask me until they've checked with all members in their group.

"When I ask them to reach consensus about the right answer, two things happen. First, I'm not the only teacher in the classroom anymore. Second, kids who get the concepts quickly reinforce their own understanding by teaching others. And, oftentimes, kids can explain these things to other kids a whole lot better than I can. So they do the teaching, and I have an opportunity to better understand each student's progress because I have more time to watch them. They work the problems at the board or the overhead, and I watch.

"You know, I used to be performing all the time. I gave all my attention to my own performance — demonstrating problems, explaining answers — and didn't have time to watch the kids. I know my students one whale of a lot better now.

Textbooks as Resources

"Another difference is that I don't use the textbook the way I used to. Paulette really helped our department to look at textbooks critically. Do you realize that every textbook organizes Algebra I, for example, differently? The order is different and the skills and concepts they cover are different. I figure if they can't reach consensus on what to teach when, then I probably should trust my own experience from working with kids every day.

"I've gotten so that we use the textbook as a resource. It's a place where the kids can go to find out how to do the things they need to do. We skip around. I may think right triangles should be taught before other things, or I may decide in Algebra II that my group should go right to slopes of lines, which is in the middle of the book. When we do project work, I may cover three different chapters at once. I help the kids to see where the explanations of the formulas are in their book so they can use the book as a supplement to the classroom demonstrations.

"Kids tell me that I don't give them the answers. Ten years ago I would have thought that was an insult. Now, I think it's a compliment. Now, I want *them* to do the thinking!"

Quality before Coverage

"I also feel a difference in the pace of the classroom because we are making some discoveries about coverage. Coverage — getting through all the material in the book — used to be the most important thing to me. I believed that if I didn't get through it all, the people who were teaching the courses after me would be stuck. Well, we've been discovering that there is a lot of overlap in math texts and in math curriculum. I ask the kids a lot more questions these days. Whenever we start something new, I ask them, 'Where have you seen this before? What parts of this formula do you know how to work?' I'm surprised at how often the kids can locate the parts they do know.

"Then, too, when I was fussing over coverage, I kind of ignored whether the kids were really getting it or not. The pace of the classroom was so fast, and I was so busy doing everything, that I didn't take much time out to think about whether I was satisfied with the *quality* of what they knew. I discovered that while they could plug figures into problems they were familiar with, they couldn't really think their way through different kinds of applications. Well, I want them to be able to do that, to think and to really use the stuff we are learning, and that takes more time. Now I give kids a list of the skills and concepts we'll be covering during the course of the term, and they use that as a kind of checklist. I move through those skills and concepts, watching the students' understanding. If they don't get something, we slow down and come at it again.

"The other math teachers and I are talking about what things should be taught in Algebra I and what should be left for Algebra II. We're talking about what algebra skills the kids really need in order to do geometry. So we're trying to find ways to slow down, to help the kids learn more thoroughly.

Teacher-as-Facilitator

"All these changes have influenced the way I work in the classroom. I lecture a lot less — hardly ever more than five or ten minutes — and the kids do a lot more work a lot more of the time. I get them working in their groups quicker than I used to. Rather than me standing up there and going over things for them, I let them try it out so I can watch

and see where they get stuck. I move from group to group, and I can tell you, there are days when I really wish I could wear roller skates or that I had some kind of a circular skateboard so I could get around that room faster! I spend my time figuring out how to get them engaged — through problem-solving and such like — and how to get them unstuck when they get mired down, through analyzing how they are doing things and trouble-shooting. It really is a different way of working. Like I said, I concentrate on their performance now, not on mine.

"Now, I have to say that I'm still learning, so I do spend a fair bit of time examining my own teaching. But I'm even looking at that differently. When kids didn't get something before, I used to look at the kids. What were they doing? Goofing off? Missing class? Now, like as not, I look at what I did. Did I give them a good example? Was the problem too complex for the concept? Did I talk too long? Did I leave out a step?

"And I ask a lot more questions. Instead of giving kids information, I try to get them to give me information, so I ask questions. I also want them to make the connections, to see that one math concept builds on another, so I want them to see what parts of something they've worked with before. I want them to be able to use the concepts in real applications, so I ask those kinds of questions. And in order to ask all of these questions, I'm asking myself a lot more questions, too."

DIFFICULTIES IN THE MIDST OF CHANGE

Throughout our discussion, Jennifer mentioned frequently that these change was difficult and that there were a number of factors that inhibited her progress. "There are two things which keep me from going ninety miles an hour. One is just my own fears. And the other is that it is really difficult to change.

Fear of Change

"Sometimes I am afraid that I just plain don't know enough, that the kids will ask me something that I don't know and that the whole thing will come apart at the seams.

"I've also worried about the coverage issue a whole lot. I was raised to think that we had to cover, cover, cover, so there are days when I'm afraid that my students won't do well on placement tests. Too, I'm so new to this that I'm not sure yet what should be taught at what level, what can be left out one year to be taught another. I feel like these kids are on a journey, and if they don't get to where they're supposed to be, they'll be behind for the rest of that journey. I want to trust the instincts my colleagues and I are having, but I have a lot of years of training to contend with.

"Sometimes I worry about my role as a teacher. I think, 'I'm getting paid to teach. I should be doing the teaching.' It is a funny fear and a kind of confusion about what teachers are really supposed to do and what they are not supposed to do. Since I am changing the way I feel about this, sometimes I am uncertain and it makes me nervous.

"I am afraid about the transition we're about to go through. My colleagues, the kids, and I have worked really hard over the past couple of years, and I think we are learning some very important things. If the new principal doesn't support what we're doing, our program could be scuttled in no time. I would almost have to quit teaching if that were the case. I don't think I can go back now I've begun. Plus, we've gotten used to makin[illegible] of the decisions. It would be hard to give that [illegible]

Difficulty of Change

"Then there are those things that are just plain hard. It's been hard for me to learn to listen to the kids and not to interrupt them. I have to hold myself back a lot of the time because the truth of the matter is, I like to talk. I've always liked to talk. It's hard to listen to the kids struggling and stumbling along. Sometimes, I do not have the patience to wait, especially when I know the answer. I have to talk to myself constantly about this.

"Then, there are days when I think the big difficulty is working with other adults. On one of our teams we have two people who just do not get along. Also, we constantly struggle with the larger faculty — how to keep them informed, how to help them to understand what we want to do without making them feel angry or threatened. The AP teachers say we can do whatever we want as long as we don't touch their AP kids, and yet I think the OTL program would be real good for some of those kids. I think the kids are much easier to deal with than the grown-ups. It's hard to know how to get them to see eye to eye, and it makes me exhausted trying to figure it out.

"It's also hard to get the kids used to working together — to get them to trust each other and to

help each other out. The high achievers don't want to work in groups. They say that they've worked hard to get where they are and they think other kids should work just as hard. Then we have kids who don't believe in themselves, and it's hard to get them to open up to other kids who might want to help them. I think the kids also fought having to think. We felt like they were pushing against us with everything they had to keep from having to do any work. They'd all spent years perfecting passive participation, and they didn't like being asked to change.

"And another thing. It's hard to do this when there aren't any models out there to follow and when there aren't very many materials. There aren't a whole lot of high school teachers who are trying to do these things and there are even fewer math teachers, so we kind of have to make things up as we go. Textbooks aren't organized to foster this kind of teaching so we have to generate a lot of our own stuff and learn to be even better scrounges than we were before.

"The hardest thing of all, though, was to admit that we were good teachers, and then to recognize that after a number of years at teaching, we might want to do things differently. We sort of felt that if we admitted that we might need to change, it would mean that everything we'd done before was no good, and the thought of that was just plain too painful. It held me back for a couple of years. Getting to the point where we didn't feel defensive, where we could actually believe that we were good but working on being better was a real hard place to reach.

"Since we got there, it has been difficult coming up with the courage to follow our instincts in the face of years of practice. Somehow or another, I think we as teachers do not believe really that we know what's best for kids nor do we believe that we have the authority to change long-time practices. I am constantly trying to dig up more confidence, more courage to believe in myself."

FACILITATING CHANGE

As a teacher myself, I found that many of the difficulties Jennifer and her colleagues experienced rang true. When I listened to her, I felt the exhaustion that comes with the effort such change requires. In the face of such difficulties, I wondered what sorts of things kept her going. Jennifer beamed and reminded me that she loved to talk about these things, especially because they were more positive, more uplifting. These were the things she thought about when she was having a bad day — just to keep her going. She talked so fast, it was hard to keep up!

The Kids

"I have to say that the most important factor which keeps me going is the kids. The kids are sensitive, you know. They understand that we are attempting to change and they just seem to read our moods. If I'm having a bad day, they seem to know it and to give me a little space. Then, they put some of my worst fears to bed. They let me know straight away that it was okay with them if I didn't have all the answers. I think it's a little comforting to them to know that teachers don't know everything, that we're still trying to learn too.

"I can't tell you how many times the kids have surprised me. In problem-solving and in project work, they end up tackling things I would never have thought they were ready for, and they do a good job — makes me feel a little guilty, like I've been holding them back all this time. Those kids can do things I never gave them the foundation to do, and it's just great to watch them do that kind of thinking on their own.

"Another thing with the kids is that I think they are developing better leadership skills in my class now. Since they have been working in groups and since they've gotten used to helping each other, they know how to organize themselves, they know how to present their ideas, they know how to argue — all those kinds of communications skills that good leaders need. It's fun to watch them grow.

"Finally, I have to say that I have not seen my students' test scores drop one bit in the two years since I changed the way we've done things, so that has kept me going, too."

Empowering Leadership

"Besides the kids, if I look back at what made me want to change, three more things stand out. The first is the leadership we've had here at Riverdale, both in the math department and from the principal. Before the Coalition hit town, Paulette, as the math department chair, had us examining textbooks for coherence and such like. Well, that was a major breakthrough for me. Each text included some things that others didn't. Each

put the content in a different order. None of them asked the kids to really stretch, to be able to think through another application of a concept. That exercise helped me to understand that there is more flexibility in math than I had ever thought about before.

"Then, we talked about tests. I can remember when she told me that the chapter tests were too easy for the kids. I wondered where she was importing her students from! We started experimenting with different kinds of tests — stretch tests, tests kids didn't have to finish, tests where kids could select the problems they wanted to work on, group tests. All of this really pushed me to be more flexible — a quality math teachers are not known for.

"Then, too, Paulette treated me as if I were a resource to her. Here she'd been teaching a lot longer and she is just about the best loved and most innovative teacher in the school, and she would use stuff I brought in with her own classes. That made me feel as if I were really contributing.

"Dr. Jamison has been a different kind of principal. He really trusts us. He has shared his own beliefs with us, as well as his doubts about what we're doing well and poorly here. He found money to send us to conferences. He provided reading material on current issues. He got us talking. When my colleagues and I went to Louisville and came back full of plans, he was all for it and let us know that while he would support us 100 percent, we should plan to run our own program. No one had ever given us that kind of authority, and I have to say that while it was frightening at first, now it feels right."

A Chance to Practice Change

"While I was making some of the changes I mentioned with testing and with textbooks, I hadn't really changed the way I was teaching, which leads me to the second thing which stands out in my mind as helping me to change. It was an experience my principal provided that really enabled me to try some things out.

"I still couldn't see how to apply a lot of the things people in the Coalition were talking about in a math classroom. Three years ago the principal asked us to do a kind of advisory group, which we called Forum. It was a place to cover current events, to get to know the kids better, and to help them get through school. It was a safe place for me to experiment because there were no grades and no exams to be taken. I had a small group of kids, and for the first couple of weeks I worked my tail off to keep them entertained. Finally , I stopped and told them that they were going to have to get involved. So, we set up a few projects, and the kids took charge.

"We started by investigating public education, which was being battered as usual by the local media. We went to a board meeting because the board was looking for a new superintendent. Then, we read stuff — stuff from magazines and from newspapers. The kids brought visitors in. We went out to dinner. We had a great time that year. I really got to know those kids well and got to like them a whole lot, too. It showed me that personalization is really important to a kid's learning. It was in that class that I began to realize how detached kids are from school and how little they know each other. I began to notice how doggone passive they are. I put them into pairs just to see if I couldn't get them a little fired up. I had such a good time with that group, and they liked the class so much, that the principal asked us to share what we were doing with other faculty members.

"Having all that fun with that group, and then going back to my regular math teaching made me do some thinking. I began to hear the math kids a little better and noticed that they really did get stuck with some of the concepts over and over, but because we were in a hurry, I'd just give the test and keep going. It became apparent to me that the kids could not do a lot of thinking about what they were learning and that didn't seem right to me. They learned to survive, but they didn't learn to think. Now it irritates the heck out of me when some math teacher I am working with says, 'My students just don't think.' I want to ask, 'Well, do you give them a chance? I didn't.'"

A Framework for Change

"There's another factor that helped me out. While the experience with the Forums showed me how I might try some of the principles in action, the symposium and the connection with the Coalition gave me some framework for my thinking. First off, the Common Principles are classroom-based. They deal with things that go on in the classroom — personalization, student engagement, student as worker, using their minds well. It was the first time anyone had ever said to me, 'Look, the changes have to take place in the classroom. And it's got to start with the teacher. It doesn't

start with the superintendent and work its way down.'

"That's what keyed me in and made me think that I really had to do something myself. It made me want to read everything I could get my hands on. Now *I'm* putting articles in the mailboxes of other teachers, and I'm sure they feel about me like we used to feel about Dr. Jamison when he was doing his doctoral work! The belief that changes must come from the classroom has led me to feel that I can make a difference. I feel that if I only change my own classroom, I have made a difference. Then, if I manage to bring a few other teachers along too, well, that's really making a *big* difference."

WHAT'S NEXT?

I asked Jennifer what she thought was in store for her and her colleagues, what she thought they would do next, how they would proceed.

"Well, we'll add another team next year. The schedule is almost done, and the kids have signed up. The popularity of the program is growing so much that we might have to expand the tenth-grade team, and there are teachers who are willing to volunteer to work with us. We're all praying that the new principal will be supportive, and you can bet that we will meet with him right away.

"Personally, I think I'll stick to my belief that one teacher can make a difference. Sure it takes other things — a principal that supports change, mentors who lead you out to risk, teachers who want to work together, peers who support change. It does take all that. But since I've started this, I've started feeling like I could make a difference, and that knowledge has made me feel a whole lot more professional. At the same time, I've started seeing the results of the small changes I have made paying off in the classroom — my kids becoming more responsible, more curious, more supportive of one another, more thorough in their work, better able to defend their choices, willing to tackle stuff they've never had before. I'll tell you what. All of this has turned me into a learner in my own classroom. I want to learn world geography, biology, history, you name it. I want to learn more about my students and about my own teaching.

"Truth of the matter is, I didn't expect to feel so energized by all of this. Earlier on, after I'd been teaching for eight or ten years, I felt more tired, more frustrated. I could see myself getting into a real rut. But that sure hasn't happened. I'm learning from my kids when they bring stuff in for their projects. I'm learning from my colleagues. I'm growing and so are my kids.

"Now, I don't want you to think that I think that it will all be roses from here on out. I know that there will still be days when I don't think all this change business is working, days when I just want quiet, when I don't want those kids asking any questions. I've had a lot of days already when I thought that the kids were too social, where the room was a mess from all the materials, when nothing I did seemed to work. But the second year has been easier than the first, and I'm sure that the third year will cut those difficulties back a bit more.

"And it doesn't bother me to think that I've got a long way to go. I wouldn't say that I'm a strictly conventional teacher anymore, but I wouldn't say that I'm an expert teacher-as-coach either. I'd say that, to use a familiar metaphor, the biscuits aren't out of the oven yet. In fact, I'm not sure they're even *in* the oven! We're still mixing the batter — trying to find the right ingredients — a little soda, a little baking powder. Trying to figure who to borrow from and who to loan a little of what we have extra . . ."

In the midst of her reverie, Jennifer caught herself; her face spread into a great big grin. "I can sure mix up metaphors, can't I? A little mathematics, a little science, a little home cooking. Any which way, as long as my students continue to come to class more willing to tackle problems, to work hard, and as long as they keep surprising me with what they can do, I'm going to keep working on my own formula for better math teaching."

NOTES

[1] This case study was done in order to document and to better understand the pedagogical changes a math teacher made as she attempted to help her students learn to use their minds well. The data was gathered during the 1989–90 school year. I shadowed Jennifer for one week, interviewed her, her students, and her colleagues and took extensive observational notes. In the process of writing the case, the manuscript was swapped back and forth and additional telephone interviews were conducted. This paper includes Jennifer's description of her past teaching practices and presents a typical day now in her classroom as I observed it. Jennifer and I worked together in the development of this case; she feels that it accurately reflects her journey to more student-centered teaching and the conditions that supported and blocked the change process. For an analysis of the circum-stances described herein, see Wasley, "Stirring the Chalkdust: Three Teachers in the Midst of Change," Studies in Teacher Change, no. 4 (Coalition of Essential Schools, Brown University, 1990).

[2] In these studies, the teachers and I settled on the term "conventional" to describe their previous teaching practices. The predominant image of a conventional teacher suggests that the teacher is the deliverer of knowledge and that students are empty vessels ready to be filled with important information. Jennifer believed that it was this image of teaching that her undergraduate degrees prepared her to undertake and that this was the predominant image of teaching she had experienced in her own life in schools as a student.

It is important to note that there are both brilliant and dismal conventional teachers. Familiar literature, television, and contemporary films abound with examples. Good conventional teachers are exemplified by Mr. Chips, Miss Brooks, Mrs. Zajac in *Among Schoolchildren*, and Robin Williams's character in *Dead Poets Society*. Examples of dismal conventional teachers can be found in the works of Charles Dickens and Mark Twain and in the movies *Teachers* and *Ferris Bueller's Day Off*.

[3] Theodore R. Sizer is the chairman of the Coalition of Essential Schools and the author of *Horace's Compromise*, which presents the findings from A Study of High Schools, a major review of contemporary American high schools. In order to characterize a more productive relationship between students and teachers, Sizer outlined nine Common Principles which might motivate the redesigning of American secondary education.

The Coalition of Essential Schools, a collaboration between Brown University and schools across the country, was formed to experiment with the redesign of secondary schools through the adaptation of those principles in a variety of schools. For a full list of the principles, see Appendix A.

[4] Student-as-worker refers to the fourth Common Principle and implies that knowledge is constructed by the learner, not handed over by the teacher. Further, it implies that the goal of classroom activity is to teach students to be self-regulating and enterprising learners. This means that the work they do must help them to develop the skills to learn — the skills of question-formulation, investigation, synthesis, and analysis, among others. The work students are asked to do must be educative, with a clear performance objective in mind, so that the larger purpose of any given activity is to help the student make independent choices. For a fuller discussion, see Grant Wiggins, "The Metaphor of Student-As-Worker" (Coalition of Essential Schools, Brown University, 1988).

[5] Jennifer had obtained this exercise from the Connecticut Multi-state Performance Assessment Collaborative Team (Compact), a project sponsored by the Connecticut State Department of Education and the National Science Foundation to develop rigorous state-level math and science assessment instruments. For a copy of the complete dog-pen problem or for more information on the Connecticut project, contact Joan Baron, Box 2219, Connecticut Department of Education, Hartford, CT 06145.

Appendix A

THE COMMON PRINCIPLES

1. The school should focus on helping adolescents learn to use their minds well. Schools should not attempt to be "comprehensive" if such a claim is made at the expense of the school's central intellectual purpose.

2. The school's goals should be simple: that each student master a limited number of essential skills and areas of knowledge. While these skills and areas will, to varying degrees, reflect the traditional academic disciplines, the program's design should be shaped by the intellectual and imaginative powers and competencies that students need, rather than necessarily by "subjects" as conventionally defined. The aphorism "Less Is More" should dominate: curricular decisions should be guided by the aim of thorough student mastery and achievement rather than by an effort merely to cover content.

3. The school's goals should apply to all students, while the means to these goals will vary as those students themselves vary. School practice should be tailor-made to meet the needs of every group or class of adolescents.

4. Teaching and learning should be personalized to the maximum feasible extent. Efforts should be directed toward a goal that no teacher have direct responsibility for more than 80 students. To capitalize on this personalization, decisions about the details of the course of study, the use of students' and teachers' time and the choice of teaching materials and specific pedagogies must be unreservedly placed in the hands of the principal and staff.

5. The governing practical metaphor of the school should be student-as-worker rather than the more familiar metaphor of teacher-as-deliverer-of-instructional-services. Accordingly, a prominent pedagogy will be coaching, to provoke students to learn how to learn and thus to teach themselves.

6. Students entering secondary school studies are those who can show competence in language and elementary mathematics. Students of traditional high school age but not yet at appropriate levels of competence to enter secondary school studies will be provided intensive remedial work to assist them quickly to meet these standards. The diploma should be awarded upon a successful final demonstration of mastery for graduation — an "Exhibition." This Exhibition by the student of his or her grasp of the central skills and knowledge of the school's program may be jointly administered by the faculty and by higher authorities. As the diploma is awarded when earned, the school's program proceeds with no strict age grading and with no system of "credits earned" by "time spent" in class. The emphasis is on the students' demonstration that they can do important things.

7. The tone of the school should explicitly and self-consciously stress values of unanxious expectation ("I won't threaten you but I expect much of you"), of trust (until abused) and of decency (the values of fairness, generosity and tolerance). Incentives appropriate to the school's particular students and teachers should be emphasized, and parents should be treated as essential collaborators.

8. The principal and teachers should perceive themselves as generalists first (teachers and scholars in general education) and specialists second (experts in but one particular discipline). Staff should expect multiple obligations (teacher-counselor-manager) and a sense of commitment to the entire school.

9. Ultimate administrative and budget targets should include, in addition to total student loads per teacher of eighty or fewer pupils, substantial time for collective planning by teachers, competitive salaries for staff and an ultimate per pupil cost not to exceed that at traditional schools by more than 10 percent. To accomplish this, administrative plans may have to show the phased reduction or elimination of some services now provided students in many traditional comprehensive secondary schools.

Appendix B

CHOOSE THE BEST GRAPH

OBJECTIVE: To interpret graphical data.

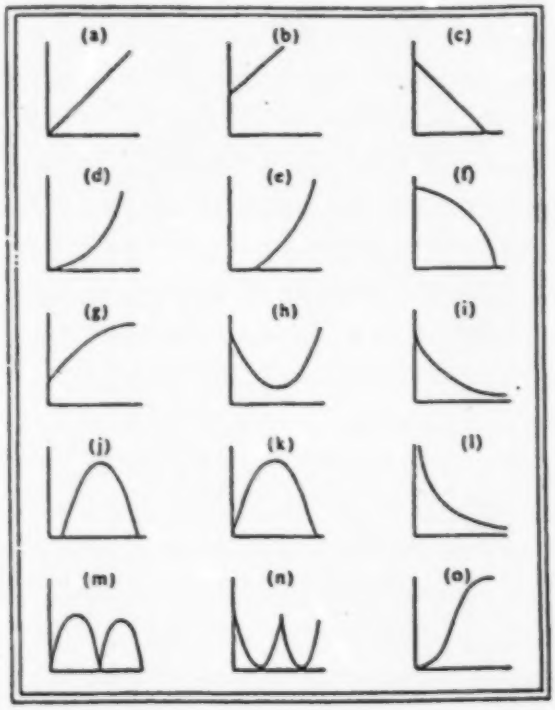
MATERIALS NEEDED: A set of graphs and statements for each pair of students.

DIRECTIONS: Choose the best graph to fit each of the following situations. A graph may fit more than one situation. If you cannot find the graph you want, draw your own version.

1. Prices are now rising more slowly than at any time during the last five years.
2. I really enjoy cold milk or hot milk, but I hate lukewarm milk!
3. The smaller the boxes are, then the more boxes we can load into the van.
4. After the concert there was a stunned silence. Then one person in the audience began to clap. Gradually those around her joined in and soon everyone was applauding and cheering.
5. If movie admission charges are too low, then the owners will lose money. On the other hand, if they are too high, then few people will attend and again they will lose. A movie theatre must therefore charge a moderate price in order to stay profitable.

In questions 6–10, you have to decide what happens. Explain carefully in words and choose the best graph.

6. How does the cost of a bag of potatoes depend on its weight?
7. How does the diameter of a balloon vary as air is slowly released from it?
8. How does the time for running a race depend upon the length of the race?
9. How does the speed of a girl vary on a swing?
10. How does the speed of a ball vary as it bounces along?

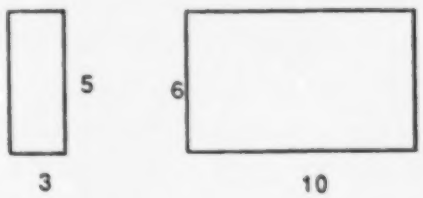


REFERENCE: Swan, Malcolm. *The Language of Functions and Graphs*. Shell Centre for Mathematical Education, University of Nottingham, England. Dale Seymour Publications.

SIMILAR REGIONS

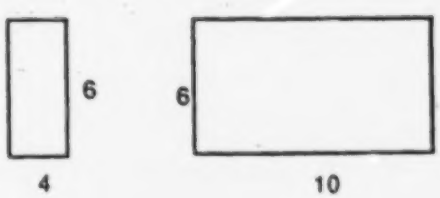
Definition: *Two regions are similar* if all corresponding distances are in proportion. This means that there is a constant of proportionality **k** by which a distance in the first region can be multiplied to find the corresponding distance in the second region. This definition is easier to apply if the corresponding regions are polygons. This identifies a number of corresponding distances.

1. Use the definition above to determine whether the two rectangles below are similar.

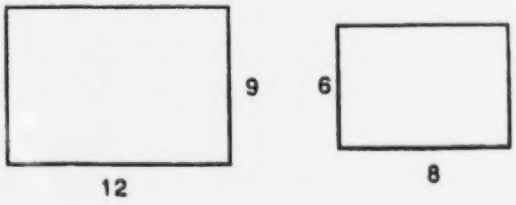


   a) Mark the corresponding sides of each rectangle with the same symbols.
   b) By what constant must the short side of the first rectangle be multiplied to get the short side of the second rectangle?
   c) By what constant must the long side of the first rectangle be multiplied to get the long side of the second rectangle?
   d) Draw in a diagonal of each rectangle and find the length of each.
   e) By what constant must the length of the first diagonal be multiplied to get the length of the second diagonal?
   f) At this time do you think that the two rectangles are similar?
   g) Find the area of each rectangle and find the constant by which the first area must be multiplied to get the second area.
   h) Are the two rectangles similar?

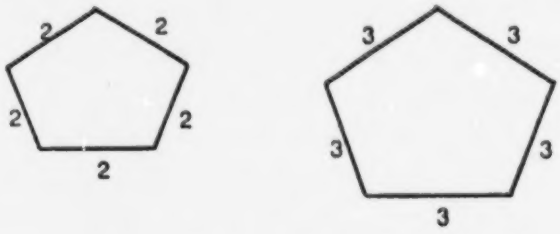
2. Determine whether the rectangles below are similar. If they are similar, what is the constant of proportionality?



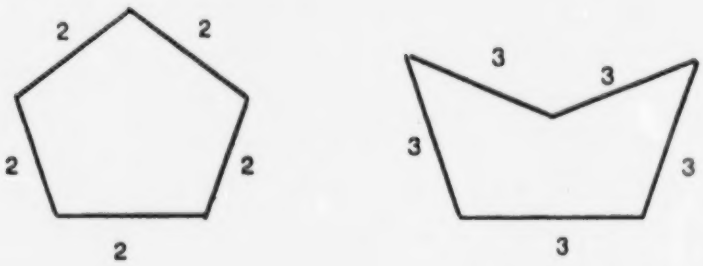
3. Determine whether the regions below are similar. If they are similar, what is the constant of proportionality?



4. Determine whether the following pentagons are similar. If they are similar, what is the constant of proportionality?



5. Determine whether the following pentagons are similar. If they are similar, what is the constant of proportionality?



6. Reread the definition of similar. Is it sufficient to know the measure of the sides of the polygons to determine whether they are similar?

7. Are all equilateral polygons regular? Make drawings before you decide.

8. a) Are all circles similar?
   b) Are all squares similar?
   c) Are all equilateral triangles similar?
   d) Are all regular n-gons similar?

9. If the lengths of the sides of polygons do not provide enough information to determine whether the polygons are similar, could you decide what other information you would need? What?

10. Sketch a few squares which you know are similar and find the constant of proportionality for them. Now *Continued on p. 8.*

SIMILAR REGIONS *(Cont'd. from p. 5)*

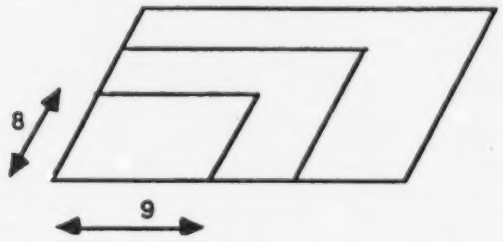
find their areas. What is the ratio of their areas? Can you describe a pattern? If you cannot, then try more cases.

11. Repeat problem 10 with polygons which are not squares. Would the same thing be true for circles?

NOTE: Properties of similarity that hold for regions in general hold for triangles. However, triangles form special cases. This means that the similarity properties of triangles cannot be generalized to other regions or even other polygons.

12. Why can the similarity properties of triangles not be generalized?
Hints:
a) Are all triangles convex?
b) Are equilateral triangles regular?
c) How many degrees in a triangle?
d) What is the simplest polygon?
e) Can any other polygon be separated into triangles?

13. Look at the following diagram of a parallelogram and other parallelograms formed from it by adding the same amount to each side. Select the proper addition which gives a new parallelogram which is similar to the first.



Contributed by Guy Mauldin, Johnson City Schools

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